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## Olivine compositions from the Hawaii Scientific Drilling Project, Phase 2: Evidence for a peridotite mantle source region

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To the extent that mantle plumes reflect whole mantle convection, Hawaii may provide the clearest window into Earth's lower mantle. Samples from the Hawaii Scientific Drilling Project (HSDP) thus provide valuable tests for models of mantle mineralogy and composition. In this vein, it has been argued recently that Hawaiian olivines, especially those from the shield-building phase as sampled by HSDP, are so high in Ni (Sobolev et al., 2005, 2007), and that Hawaiian whole rocks are so low in CaO (Herzberg, 2006) and high in  $\text{SiO}_2$  (Hauri, 1996) that a peridotite mantle source cannot generate such compositions. The Hawaiian plume, so the argument goes, is thus supposedly rich in pyroxenite, and possibly olivine-free. However, comparisons of HSDP olivines to lherzolites, and HSDP whole rocks to lherzolites and partial melting experiments belie these premises. Testable predictions of the pyroxenite model also fail. New comparisons instead show that Hawaiian lavas can be produced from a peridotite source.

First, it is unclear that the Hawaiian source is enriched in NiO. The NiO contents of olivines hosted by lherzolites (GEOROC) have the same range as olivines from the HSDP; indeed, the maximum NiO for olivines from lherzolites (0.6 wt. %) is as high as that reported for olivines from any oceanic volcano locality. There is a compositional separation between lherzolite- and HSDP-hosted olivines. But HSDP olivines are not NiO enriched so much as lherzolite olivines are higher in Fo at a given NiO. Lower Fo contents at Hawaii (at a given NiO) ensue because olivine compositions there follow a liquid line of descent, where both Ni and Mg decrease with differentiation. In contrast, subsolidus equilibria involving orthopyroxene enforce a higher and less variable Fo content for lherzolite-derived olivines. Moreover, the pyroxenite mantle model predicts that whole rocks with low CaO and high  $\text{SiO}_2$  should host olivines with high NiO. But in HSDP samples, neither correlation is evident. Whole rock compositions also support the peridotite mantle view. Primitive HSDP lavas (15%  $\text{MgO}$ ;  $F=0.2$ ;  $D(\text{Ni})=4.2$ ) indicate that the Hawaiian mantle has  $\text{Ni}=1962$  ppm, remarkably similar to estimates of pyrolite mantle (1960 ppm; McDonough and Sun, 1990) and somewhat less than the average lherzolite (2165 ppm). Ni contents at Hawaii are higher than MORB, but that is because the MORB source is Ni-depleted (relative to lherzolites), rather than the Hawaiian source being enriched. Finally, experimentally produced, peridotite-equilibrated liquids bracket the compositions of primitive HSDP lavas for all oxides but  $\text{TiO}_2$ . One experiment in particular (Takahashi et al., 1993; 46 kbar, 1720°C) comes remarkably close to reproducing primitive HSDP compositions.  $\text{TiO}_2$ , the sole exception, must be 0.68 wt. % in the Hawaiian source ( $F=0.2$ ;  $D(\text{TiO}_2)=0.21$ ), which falls at the 99.8% quantile for lherzolite  $\text{TiO}_2$

contents. Enrichments are not isolated to Ti, but extend to other high field strength elements (Hf, Zr and Y), and moderately incompatible elements (Eu, Na); none, however, require mantle source concentrations in excess of observed lherzolite values. These same enrichments are evident, though more subdued, in the MORB mantle source, and so are apparently characteristic of the convective mantle.

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